Electronic Version
Stylesheet Version v1.1.1

Claims

[c1] 1.A de-blocking filter for smoothing block edges of de-compressed images comprising:
a maximum generator for generating a maximum-allowed edge-pixel difference as a function of a quantization parameter, the quantization parameter indicating a degree of compression of an image;
a difference generator, receiving pixel components from an edge pair of adjacent pixels in adjacent blocks, for generating an edge-pixel difference;
a limiter, receiving the maximum-allowed edge-pixel difference and the edge-pixel difference, for generating a difference term, the difference term being the edge-pixel difference when the edge-pixel difference is less than the maximum-allowed edge-pixel difference, but being the maximum-allowed edge-pixel difference when the edge-pixel difference is larger than the maximum-allowed edge-pixel difference;
a fractional difference generator, receiving the difference term from the limiter, for generating a plurality of fractional differences having a decreasing range of values that are fractions of the difference term; and
an applicator, receiving pixel components from a current

row of pixels that includes the edge pair of adjacent pixels in the adjacent blocks, for adding or subtracting the fractional differences from the fractional difference generator to pixel components for pixels in the current row;
wherein successive pixels successively farther from the edge pair of adjacent pixels have successively decreasing fractional differences added or subtracted,
whereby edge-pixel differences are smoothed over the current row of pixels.

[c2] 2.The de-blocking filter of claim 1 wherein the current row of pixels comprises at least seven pixels.

[c3] 3.The de-blocking filter of claim 2 wherein the edge pair of adjacent pixels comprises a first current pixel in a current block and a first next pixel in a next block;
wherein the applicator further receives the difference term from the limiter, the applicator subtracting the difference term from the first current pixel, but adding a fractional difference to the first next pixel.

[c4] 4.The de-blocking filter of claim 3 wherein the applicator adds a fractional difference of three-fourths of the difference term to the first next pixel in the next block.

[c5] 5.The de-blocking filter of claim 4 wherein the current row of pixels comprises:

a second current pixel adjacent to the first current pixel in the current block;

a third current pixel adjacent to the second current pixel in the current block;

a fourth current pixel adjacent to the third current pixel in the current block;

a second next pixel adjacent to the first next pixel in the next block;

a third next pixel adjacent to the second next pixel in the next block.

[c6] 6.The de-blocking filter of claim 5 wherein the applicator adds a fractional difference of one-half of the difference term to the second next pixel in the next block;

wherein the applicator adds a fractional difference of one-fourth of the difference term to the third next pixel in the next block;

wherein the applicator subtracts a fractional difference of three-fourths of the difference term to the second current pixel in the current block;

wherein the applicator subtracts a fractional difference of one-half of the difference term to the third current pixel in the current block;

wherein the applicator subtracts a fractional difference of one-fourth of the difference term to the fourth current pixel in the current block.

[c7] 7.The de-blocking filter of claim 6 wherein the pixel components are luminance Y values of a YUV pixels.

[c8] 8.The de-blocking filter of claim 1 wherein the maximum generator generates the maximum-allowed edge-pixel difference as a linear function of a quantization parameter.

[c9] 9.The de-blocking filter of claim 8 wherein the maximum generator generates the maximum-allowed edge-pixel difference as one-half of the quantization parameter added to a constant.

[c10] 10.The de-blocking filter of claim 9 wherein the constant is four.

[c11] 11.The de-blocking filter of claim 1 further comprising:
a negator, receiving the maximum-allowed edge-pixel difference from the maximum generator, for generating a negative maximum-allowed edge-pixel difference;
wherein the limiter further comprises a negative limiter, receiving the negative maximum-allowed edge-pixel difference and the edge-pixel difference, for generating the difference term when the edge-pixel difference is negative, the difference term being the edge-pixel difference when the edge-pixel difference is between zero and the negative maximum-allowed edge-pixel differ-

ence, but being the negative maximum-allowed edge-pixel difference when the edge-pixel difference is more negative than the negative maximum-allowed edge-pixel difference.

[c12] 12.A computer-implemented method for smoothing blocking artifacts causes by video-image compression comprising:

receiving a series of pixels that cross a block boundary, the series comprising in sequence a first pixel, a second pixel, a third pixel, a fourth pixel, a fifth pixel, a sixth pixel, and a seventh pixel;

wherein the first, second, third, and fourth pixels are in a first block and the fifth, sixth, and seventh pixels are in a second block;

wherein the fourth pixel and the fifth pixel comprise edge pixels in the series of pixels;

generating a limit value from a quantization parameter that indicates a degree of compression of pixels in the first block;

generating a negated limit value from the limit value;

generating an edge difference value as a difference of the fourth and fifth pixels;

selecting the edge difference value as a limited difference when the edge difference value is positive and less than the limit value;

selecting the edge difference value as the limited difference when the edge difference value is negative and greater than the negated limit value;

selecting the limit value as the limited difference when the edge difference value is positive and greater than the limit value;

selecting the negated limit value as the limited difference when the edge difference value is negative and less than the negated limit value;

generating fractional differences from the limited difference;

subtracting the limited difference from the fourth pixel to smooth the fourth pixel;

adding a largest one of the fractional differences to the fifth pixel to smooth the fifth pixel;

adding a smaller one of the fractional differences to the sixth pixel to smooth the sixth pixel; and

subtracting a smaller one of the fractional differences from the third pixel to smooth the third pixel;

whereby the third, fourth, fifth, and sixth pixels in the series of pixels are smoothed with the fractional differences or the limited difference.

[c13] 13.The computer-implemented method of claim 12 further comprising:

adding a smallest one of the fractional differences to the

seventh pixel to smooth the seventh pixel;
subtracting a smaller one of the fractional differences from the second pixel to smooth the second pixel; and
subtracting the smallest one of the fractional differences from the first pixel to smooth the first pixel.

[c14] 14.The computer-implemented method of claim 13 wherein the smallest one of the fractional differences is one-quarter of the limited difference;
wherein the largest one of the fractional differences is three-quarters of the limited difference;
wherein the smaller one of the fractional differences is one-half of the limited difference.

[c15] 15.The computer-implemented method of claim 12 wherein generating the edge difference value as a difference of the fourth and fifth pixels comprises generating the edge difference value as half of the difference of the fourth and fifth pixels.

[c16] 16.The computer-implemented method of claim 15 wherein the series of pixels comprise luminance Y values of YUV pixels.

[c17] 17.A computer-program product comprising:
a computer-usable medium having computer-readable program code means embodied therein for smoothing

block artifacts produced during video compression, the computer-readable program code means in the computer-program product comprising:

input means for receiving a series of pixels decompressed from a motion-picture-experts group (MPEG) compressed video stream, wherein a current series of pixels comprises at least five pixels;

maximum means for generating a maximum-allowed edge-pixel difference as a function of a quantization parameter, the quantization parameter indicating a degree of compression of an image;

difference generator means, receiving pixel components from an edge pair of adjacent pixels in adjacent blocks, for generating an edge-pixel difference;

limiter means, receiving the maximum-allowed edge-pixel difference and the edge-pixel difference, for generating a difference term, the difference term being the edge-pixel difference when the edge-pixel difference is between the maximum-allowed edge-pixel difference or a negation of the maximum-allowed edge-pixel difference, but being the maximum-allowed edge-pixel difference when the edge-pixel difference exceeds than the maximum-allowed edge-pixel difference or the negation of the maximum-allowed edge-pixel difference;

fractional difference generator means, receiving the difference term from the limiter means, for generating a

plurality of fractional differences having a decreasing range of values that are fractions of the difference term; and

applicator means, receiving pixel components from the current series of pixels that includes the edge pair of adjacent pixels in the adjacent blocks, for adding or subtracting the fractional differences from the fractional difference generator means to pixel components for pixels in the current series;

wherein successive pixels successively farther from the edge pair of adjacent pixels have successively decreasing fractional differences added or subtracted,

whereby edge-pixel differences are smoothed over the current series of pixels.

[c18] 18.The computer-program product of claim 17 wherein the edge pair of adjacent pixels comprises a first current pixel in a current block and a first next pixel in a next block;

wherein the applicator means further receives the difference term from the limiter means, the applicator means for subtracting the difference term from the first current pixel, and for adding a fractional difference to the first next pixel;

wherein the applicator means adds a fractional difference of three-fourths of the difference term to the first

next pixel in the next block.

[c19] 19.The computer-program product of claim 18 wherein the current series of pixels comprises:

a second current pixel adjacent to the first current pixel in the current block;

a third current pixel adjacent to the second current pixel in the current block;

a fourth current pixel adjacent to the third current pixel in the current block;

a second next pixel adjacent to the first next pixel in the next block;

a third next pixel adjacent to the second next pixel in the next block;

wherein the applicator means adds a fractional difference of one-half of the difference term to the second next pixel in the next block;

wherein the applicator means adds a fractional difference of one-fourth of the difference term to the third next pixel in the next block;

wherein the applicator means subtracts a fractional difference of three-fourths of the difference term to the second current pixel in the current block;

wherein the applicator means subtracts a fractional difference of one-half of the difference term to the third current pixel in the current block;

wherein the applicator means subtracts a fractional difference of one-fourth of the difference term to the fourth current pixel in the current block.

[c20] 20.The computer-program product of claim 17 wherein the pixel components are luminance Y values of a YUV pixels.